Rec. West. Aust. Mus. 1988, 14(2): 151-169

A new species of Australian *Craterocephalus* (Pisces: Atherinidae) and redescription of four other species

L.E.L.M. Crowley* and W. Ivantsoff*

Abstract

A new species of hardyhead, *Craterocephalus munroi,* from estuarine reaches of the Bynoe, Norman and Nicholson Rivers, southern Gulf of Carpentaria, is described. Morphologically the new species appears to be most closely related to *C. marjoriae* and *C. marianae* members of the *C. eyresii* group. Osteologically it is also aligned with that group, but differs in having the fifth ceratobranchials fused and no tooth plates present on first lower gill arch. The marine and estuarine species of hardyheads *(Craterocephalus honoriae, C. mugiloides, C. capreoli* and *C. pauciradiatus)* are also reviewed. The genus *Allanetta* is relegated to the synonymy of *Craterocephalus* and the relationships of these marine/estuarine hardyheads are discussed.

Introduction

Fishes of the family Atherinidae are found throughout the world, mainly in marine and estuarine habitats, but a number of genera are also found in fresh water habitats in the Americas, Madagascar and Australia. The Australian atherinid genus *Craterocephalus* comprises two distinct groups of freshwater species (the *C. eyresii* group and the *C. stercusmuscarum* group) and a marine group which includes *C. honoriae, C. capreoli* and *C. pauciradiatus* (see Ivantsoff *et al.,* 1987a). A fourth species, *C. mugiloides,* previously included in the genus *Allanetta,* is now added to the marine group. The new species *Craterocephalus munroi,* although from tidal reaches of southern Gulf of Carpentaria rivers, is not considered to belong with the marine group. Instead it appears most closely related to the freshwater *C. eyresii* group, one species of which may inhabit saline lakes (see Chessman and Williams 1974).

The taxonomic status of some species of the marine group has been controversial. *C. honoriae* was originally ascribed to the genus *Atherina* by Ogilby (1912), but in 1919, Jordan and Hubbs placed it in the genus *Craterocephalus* and were followed by McCulloch and Whitley in 1925. Schultz (1948), who erected *Stenatherina,* with *S. temminckii* as the type species (erroneously identified *S. temminckii* of Schultz, is indistinguishable from *A. panatela* Jordan and Richardson, 1908) suggested that *C. honoriae* should also be placed into this new genus. Subsequently, Munro (1958) and Thomson (1959) followed Schultz, but this placement was disputed by Ivantsoff (1978) who gave a number of characters distinguishing *C. honoriae* from *Stenatherina.*

* School of Biological Sciences, Macquarie University, New South Wales 2109.

Craterocephalus mugiloides was previously ascribed to the genus *Allanetta* (Whitley, 1943), but was considered to be closely related to *Craterocephalus* by Taylor (1964). Whilst this spccies was maintained in a separate genus by Ivantsoff (1978), he noted the many similarities of this species and *C. honoriae*, and stated 'It is contcntious whether *A. mugiloides* deserves a generic status of its own'. Patten (1978), who suggested it should be regarded as a subgenus within *Craterocephalus*, said he could find no advanced osteological characters separating *Craterocephalus* and *Allanetta*. The present study indicates that *Allanetta* must be placed into the synonymy of *Craterocephalus*.

Taylor (1964), recognised *C. capreoli* as a junior synonym of *C. pauciradiatus* without comment. This synonymy was followed by Ivantsoff (1978) but subsequent examination of the holotype of *C. pauciradiatus* by the latter, showed distinct differences between thcse two species.

A specimen of *Craterocephalus* sp., collected by Mr I.S.R. Munro some years ago from Norman River, Queensland, was tcntatively identified by him as new, or very close to *Craterocephalus marjoriae* (pers. comm.). Examination of several other Australian Museum specimens from the same area, as wcll as some specimens recently collected from Bynoe River, confirm that they belong to a new species which is morphologically similar to *C. marjoriae*. Osteologically, thc new specics is distinct but is considered to be aligned with thc *C. eyresii* species group (of which *C. marjoriae* is also a member).

Materials and Methods

Methods for counts and measurements arc based on Munro (1967), modificd in several instances as described by Prince *et al.*, (1982) and Patten and Ivantsoff (1983). As with all other species of *Craterocephalus*, the anal and second dorsal fins may or may not havc an unbranched ray immediately following the spine and prcceding thc branchcd rays. For this reason and for the sake of uniformity, thc ray following thc spine in thesc fins is never included in the count of branchcd rays (Tables 1 and 2).

For ostcology, Taylor's (1967) method for clearing and staining small specimens was used. Drawings werc madc with the aid of camera lucida attached to a dissecting microscope.

Abbreviations used in Tables 1 and 2: SL, standard length; H. max, maximum body depth; H. min, least body depth; Pec-anus, distance from dorsal origin of pectoral fin to anus; Sn, snout; OD1, origin of first dorsal fin; OD2, origin of second dorsal fin; OV, origin of ventral fins; OA, origin of anal fin; TA, insertion of last ray of anal fin; Interorb, width of interorbital; Postorb, length of opercle from posterior edge of orbit to edge of opercle; Premax, length of premaxilla; Premax proc, dorsal premaxillary process; Posit anus, position of anus; TV, tips of ventral fins; TPec, tips of pectoral fins; F, in front; B, behind.

Table 1 Morphometric proportions and meristic counts for holotype and 29 paratypes of *Craterocephalus munroi*, mean and mode with range in brackets; SD, standard deviation.

Size mm SL	Holotype 34.3 mm	29 paratypes 25.5-35.3 mm		
		mean	range	SD
In SL				
Head	3.4	3.4	(3.2-3.7)	0.11
H. max	4.5	4.2	(3.7-4.8)	0.26
H. min	8.7	9.2	(7.8-11.2)	0.63
Pec-anus	2.7	2.7	(2.4-2.8)	0.09
Sn-OD1	2.1	2.0	(2.0-2.1)	0.05
Sn-OD2	1.4	1.4	(1.3-1.4)	0.03
Sn-OV	2.0	2.1	(2.0-2.2)	0.07
Sn-TV	1.6	1.6	(1.5-1.7)	0.06
Sn-OA	1.4	1.4	(1.3-1.5)	0.03
Sn-TA	1.2	1.2	(1.2-1.3)	0.04
In Head				
Eye	3.2	3.2	(3.0-3.5)	0.13
Interorb	3.3	3.2	(2.9-3.5)	0.14
Postorb	2.3	2.4	(2.2-2.5)	0.08
In Eye				
Sn	1.1	1.1	(1.0-1.2)	0.07
Premax	1.2	1.1	(1.0-1.2)	0.06
Premax proc	1.6	1.6	(1.4-1.7)	0.09
Scale counts				
Midlateral	28	27-28	(26-29)	
Transverse	7	7	(6-8)	
Interdorsal	6	6	(5-7)	
Fin elements				
First dorsal	7	6	(5-7)	
Second dorsal	5	5	(4-6)	
Anal	6	6	(5-6)	
Pectoral	13	13-14	(12-14)	
Other values				
Gill rakers	11	11	(10-12)	
Vertebrae	30	*30	(29-31)	
Posit anus	B0	B0-1	(B0-2)	
OD1-TV	F5	F5	(F4-6)	
OD1-TPec	0	F0-1	(B0.5-F2)	
OV-TPec	F0.5	F1	(F0.5-2.5)	

*only 25 specimens counted

Table 2 Morphometric proportions and meristic counts of four marine/estuarine species of hardyheads, *C. mugiloides, C. honoriae, C. capreoli* and *C. pauciradiatus;* mean and mode with range in brackets. Abbreviations as in Table 1.

	C. mugiloides	*C. honoriae*	*C. capreoli*	*C. pauciradiatus*
Number and range in mm SL	44 (31.4-57.6)	28 (22.0-43.6)	43 (30.0-69.9)	29 (25.9-50.0)
Character				
In SL				
Head	3.7 (3.3-4.5)	3.8 (3.6-4.1)	3.8 (3.3-4.2)	3.4 (3.2-3.5)
H. max	5.2 (4.5-6.6)	5.9 (5.2-7.2)	4.9 (4.3-5.4)	4.1 (3.8-4.5)
H. min	11.4 (10.1-16.1)	12.6 (9.4-15.2)	10.6 (9.0-12.0)	9.6 (8.5-11.7)
Pec-anus	3.9 (3.5-4.7)	3.7 (3.4-4.2)	4.2 (3.7-4.6)	3.3 (3.2-3.6)
Sn-OD1	2.0 (1.8-2.2)	2.0 (1.9-2.2)	1.9 (1.8-2.0)	1.8 (1.7-1.9)
Sn-OD2	1.4 (1.3-1.6)	1.4 (1.4-1.5)	1.4 (1.3-1.5)	1.3 (1.2-1.4)
Sn-OV	2.4 (2.2-2.7)	2.4 (2.1-2.6)	2.3 (2.2-2.5)	2.2 (2.1-2.3)
Sn-OA	1.5 (1.4-1.6)	1.5 (1.4-1.6)	1.4 (1.4-1.5)	1.4 (1.4-1.5)
Sn-TA	1.2 (1.2-1.3)	1.3 (1.2-1.3)	1.2 (1.2-1.3)	1.3 (1.2-1.3)
In Head				
Eye	3.2 (2.5-3.3)	2.8 (2.6-3.1)	3.2 (2.8-3.4)	3.3 (3.2-3.5)
Interorb	2.8 (2.3-3.8)	2.9 (2.5-3.5)	2.6 (2.1-3.1)	2.6 (2.5-2.7)
Postorb	2.5 (2.0-2.9)	2.5 (2.1-2.8)	2.4 (2.1-2.9)	2.3 (2.2-2.4)
In Eye				
Sn	1.2 (1.0-1.4)	1.5 (1.3-1.9)	1.2 (1.0-1.6)	1.1 (1.0-1.1)
Premax	1.0 (0.7-1.3)	1.3 (1.0-1.6)	1.1 (0.9-1.3)	1.0 (1.0-1.1)
Premax proc	1.2 (1.0-1.5)	1.5 (1.2-2.0)	1.3 (1.1-1.6)	1.1 (1.0-1.1)
Scale counts				
Midlateral	35 (33-37)	33-34 (33-36)	31 (29-33)	28-29 (27-30)
Transverse	5 (4.5-6)	5 (4.5-6)	5 (5-6)	5 (5-5.5)
Interdorsal	7 (6-9)	7 (6-8)	6 (5-7)	6 (5-6)
Fins elements				
First dorsal	6 (5-7)	5 (5-6)	5 (4-6)	5 (4-6)
Second dorsal	7 (6-9)	7 (6-7)	6 (5-7)	5 (4-5)
Anal	9 (8-12)	9 (8-11)	7-8 (6-9)	6 (5-7)
Pectoral	12 (11-14)	11-12 (11-12)	11 (10-13)	12 (11-13)
Other values				
Posit anus	F3 (F1-4)	F2 (F0.5-2)	F4 (F3-5)	F3 (F2-4)
OD1-TV	F3 (F0.5-5)	F2-2.5 (F1.5-5)	F1-1.5 (F0-2.5)	F3 (F1-3.5)
OV-TPec	F2 (0-F3)	F1.5 (B1-F2.5)	F1.5 (F0-2.5)	F2 (F0-2.5)
Vertebrae	36 (34-37)	36 (35-38)	32 (30-35)	31 (30-32)
Gill rakers	15 (13-17)	13 (12-15)	11-12 (10-13)	9 (8-9)

Cluster analysis (Figure 7) of all *Craterocephalus* species was made by using 48 osteological characters (represented by binary notation — 1/0 to indicate presence or absence; large or small, etc.). The procedure was based on an algorithm (Jacquard similarity coefficient) modified from Sneath and Sokal (1973) by Dr G.M. McKay of Macquarie University.

Material from the following institutions was examined: the Australian Museum, Sydney (AMS); British Museum of Natural History, London (BMNH); the late Dr D.E. Rosen's personal field collection number (American Museum of Natural History)(DR); Macquarie University, North Ryde (MQU); Queensland Museum, Brisbane (QM); Univeristy of Michigan, Museum of Zoology, Ann Arbor, Michigan (UMMZ); National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM); Western Australian Museum, Perth (WAM); Zoologisk Museum, Universitetets I Oslo (ZMUO). Other code in text (*C. capreoli* page 12). Presumably Naturhistoriska Riksmuseet, Stockholm (Ivantsoff 1978; but see Pethon 1969)(RMS).

Key to the Australian marine and estuarine species of *Craterocephalus*

1a Midlateral scales always 33 or more; second dorsal rays 6-9 (usually 7); fifth ceratobranchials well separated and epiotic crest small 2

1b Midlateral scales never more than 33; second dorsal rays 4-7 (usually 5 or 6); fifth ceratobranchials very close or fused, epiotic crest large and sometimes fingerlike 3

2a Single black spot at base of pectoral fin, gill rakers equal to diameter of pupil. Fifth ceratobranchials shallow triangles. Dentary lateral fossa immediately adjacent to symphysis ..... *C. mugiloides*

2b No black spot at base of pectoral fin, gill rakers relatively long but less than diameter of pupil. Fifth ceratobranchials deep triangles. Dentary lateral fossa never adjacent to symphysis ..... *C. honoriae*

3a Midlateral scales 29-33, anus 3-5 scales in front of tips of pelvic fins; gill rakers short and stumpy but never tuberculate; interdorsal pterygiophores well developed, fifth ceratobranchials very close ..... *C. capreoli*

3b Midlateral scales always 30 or less. Gill rakers tuberculate or less than half diameter of pupil; fifth ceratobranchials fused, interdorsal pterygiophores vestigial or absent 4

4a Anus always in front of tips of pelvic fins; gill rakers tuberculate and tooth plates always present on first lower gill arch; interdorsal pterygiophores always present .... *C. pauciradiatus*

4b Anus always behind tips of pelvic fins; gill rakers never longer than half diameter of pupil; tooth plates not present in first lower gill arch; interdorsal pterygiophores 1-2 vestigial, or totally absent ..... *C. munroi*

Systematics

Craterocephalus munroi sp. nov.

Figure 1

Craterocephalus marjoriae – Ivantsoff 1978: 595 (in part).

Holotype

AMS I.27329-001, 34.3 mm SL. 3 m seine in small pools, depths to 1.5 m, substrate – mud and rocks, Bynoe River, Queensland, collected by L. Crowley and W. Ivantsoff, 17 August 1987.

Paratypes

Thirty-one specimens: AMS I.27330-001 (14), data as for holotype; QM I.25026 (10), data as for holotype; WAM P.29673-001 (5), data as for holotype; BMNH 1988.3.10.1-5 (5), data as for holotype; USNM 293955 (5), data as for holotype; AMS I.27331-001 (2), Nicholson River, 20 km from Burketown, Queensland, collected by H. Midgley, 10 October 1982. Size range 25-35.5 mm SL. Measurements and counts for the holotype and 29 paratypes are presented in Table 1.

Material examined for osteology (not designated as types): MQU I.403 (3), Bynoe River; MQU I.295 (1), Nicholson River, Queensland.

Diagnosis

A fluviatile/estuarine species of *Craterocephalus* most closely related to *C. marjoriae* and *C. marianae,* but may be distinguished from those species by the proportion: pectoral to anus in SL [2.7 (2.4-2.8) v. 3.0 (2.8-3.4)] and by transverse scale count [6-8 (usually 7) v. 5.5]. Osteologically *C. munroi* may be distinguished from *C. marjoriae* and *C. marianae* in having fifth ceratobranchials fused v. unfused. *C. munroi* differs from other marine/estuarine species of this genus by the combination of the following characters: origin of pectoral to anus, 2.4-2.8 (2.7), snout to origin of ventrals, 2.0-2.2 (2.1) both in SL. Dorsal process of premaxilla 1.4-1.7 (1.6), interorbital, 2.9-3.5 (3.2) both in eye. Gill rakers short, almost stumpy or tuberculate, 10-12 (usually 11). Pectoral fin rays 12-14 (usually 13-14), anal fin rays 5-6 (usually 6). Anus at, or up to 2 scales behind tips of ventrals. Transverse scales 6-8 (usually 7). Fifth ceratobranchials fused; urohyal without ventral pocket or ventral wings; interdorsal pterygiophores absent, or if present, vestigial. Basibranchial tooth plate absent. Ribs always visible through body wall.

Description

Robust fish; mouth moderately large, lips fusing more than half way along premaxilla. Premaxilla never reaching vertical through anterior margin of orbit, its dorsal process shorter than in following species, barely reaching interorbital space. Body scales not crenulated.

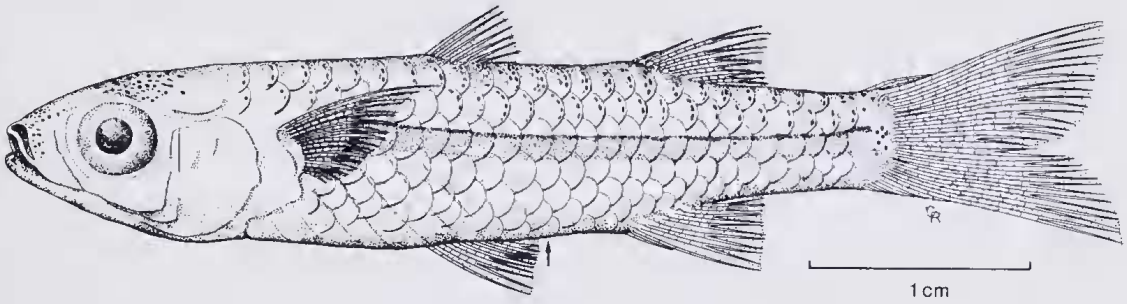

Figure 1 *Craterocephalus munroi,* holotype, AMS I.27329-001 (34.3 mm SL), Bynoe River, Queensland.

Colour: Preserved specimens yellowish to creamy-grey. Ribs outlined in black over dark peritoneal wall. Midlateral band dark, thin at dorsal origin of pectoral fin, becoming wider caudally, then breaking up into separate spots at hypural joint. Dorsal surface of head, lips, snout and opercles peppered with chromatophores. Midventral surface usually dark from origin of pectoral fins to vent; row of chromatophores from origin of anal fin to base of caudal. Upper scale pockets above midlateral band outlined with chromatophores. Fin rays of anal, dorsal and caudal also lightly pigmented. Live specimens variable, with abdomen, opercle and eye silvery or dull brown. Peritoneal cavity well outlined by silvery or brown membrane. Midlateral stripe either distinct or merging with silvery abdomen. Intensity of chromatophores over dorsal half of body variable. Fins clear.

Etymology

Named after Mr I.S.R. Munro who first suspected this fish to be new and who had always a special interest in the family Atherinidae.

Distribution

C. munroi is known only from the Norman, Bynoe and Nicholson Rivers in the southern Gulf of Carpentaria. The salinity at Bynoe River at the time of collection was 15.5 parts per thousand. It is presumed that these fish also inhabit areas of tidal influence in the other rivers.

Remarks

C. munroi is distinct from the marine/estuarine species (cf. Tables 1 and 2). It appears to be allied with species of the *C. eyresii* group but is distinct in the following: fifth ceratobranchials fused; teeth in jaws needle-like, and in more than one row; no tooth plates prcsent on first lower gill arch.

Craterocephalus mugiloides (McCulloch)

Figure 2

Atherinichthys punctatus De Vis, 1885: 869, type locality: Cape York, Queensland, 11° 48′S, 142° 21′E.

Atherina mugiloides McCulloch, 1913: 47 (replacement name for *Atherinichthys punctatus* – regarded as preoccupied by *Atherina punctata* Bennett 1832);—McCulloch 1929: 108;—Jordan and Hubbs 1919: 44; – McCulloch and Whitley 1925: 140.

Allanetta punctata – Whitley 1943: 135; – Munro 1958: 100.

Allanetta mugiloides – Schultz 1948: 22; – Schultz *et al.* 1953: 298; – Taylor 1964: 134; – Smith 1965: 621; – Ivantsoff 1978: 338.

Craterocephalus (Allanetta) mugiloides – Patten 1978: 110.

Material examined

Cape York, Queensland, holotype of *Atherinichthys punctatus*, QM I.142; paratypes AMS I. 357 (2), locality as for holotype. Other specimens: Lindeman Island, Queensland, AMS IA. 6301 (1), AMS IA.6760 (2), AMS IB.7089 (1); Groote Eylandt, Northern Territory, AMS I.15652-001 (1); AMS I.15652-003 (2); Broome, Western Australia, MQU 75-23 (10); Port Hedland, WA, MQU 75-24 (10); Point Samson (Roeburne), WA, MQU 75-25 (7); Coral Bay, WA, MQU 75-26 (8). Size range 31.4-57.6 mm standard length (SL). Forty-four specimens were used for measurements and counts (holotype excluded-poor preservation).

Material examined for osteology: Lindeman Island, Queensland, AMS IA.6076 (1); Swan River, Perth, WA, MQU 75-46 (4); Point Samson, WA, MQU I.007 (3); Port Hedland, WA, MQU 75-24 (3).

Diagnosis

An estuarine species of *Craterocephalus* most closely related to *C. honoriae*, but distinguished from that species by body colour and the presence of a black spot at the base of the pectoral fin. *C. mugiloides* also differs from *C. honoriae* in the proportion: premaxillary process in eye[1.2 (1.0-1.5) v. 1.5 (1.2-2.0)]. *C. mugiloides* differs from other marine/estuarine species of this genus by a combination of the following characters (range, mode in brackets): gill rakers relatively long, about half diameter of pupil, 13-17 (usually 16) pectoral fin rays 11-14 (usually 12); anal rays 8-12 (usually 9); midlateral scales 33-37 (usually 35). All other measurements and counts overlapping with other species (see Table 2). Labial ligament inserted adjacent to symphysis of dentary; fifth ceratobranchials shallow triangles; ethmoid cartilage often persisting in palatine facet; mesethmoid present in all populations except from Swan River.

Description

Robust fish, mouth moderately large, lips relatively thin, fusing about two-thirds way along premaxilla. Free edge of premaxilla slightly convex anteriorly and relatively straight towards angle of mouth. Premaxilla always reaching or beyond vertical through anterior margin of orbit; lateral process of premaxilla prominent. Teeth of medium size in two rows in jaws. Scales on larger specimens usually crenulated on posterior edge.

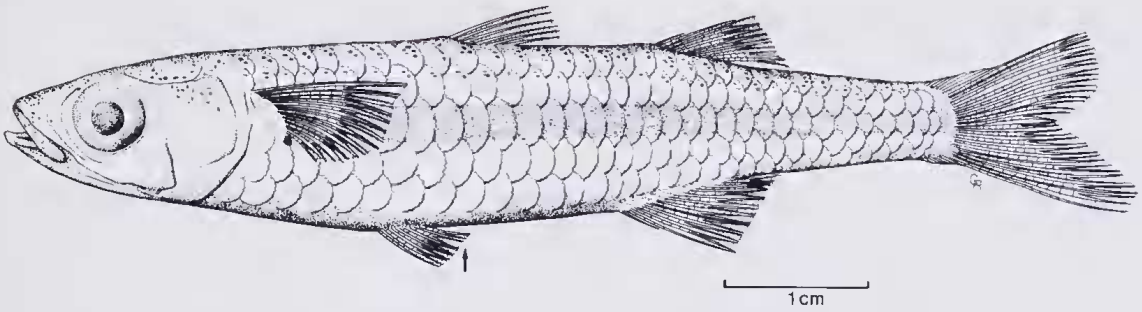

Figure 2 *Craterocephalus mugiloides*, MQU I. 421 (52.9 mm SL), Point Samson, W.A.

Colour: Preserved specimens from dark to light yellow depending on length of preservation. Dark brown or silvery band extending from origin of pectoral to base of caudal fin and expanding slightly at base of caudal rays. Distribution of chromatophores on body variable but usually with concentration of pigment at base of fins. Black blotch at lower base of pectoral fins almost always visible.

Live specimens almost translucent, dorsal surface dusky to greeny yellow with chromatophores at edges of scales. Distinct concentration of pigment along mid-dorsal line from dorsum of head to caudal fin. Snout, eye, opercle, preopercle and belly iridescent or silvery. Wide midlateral band either silvery or olive to golden with narrower orange band above it from origin of pectoral fin to hypural joint. Black spot below pectoral base very obvious. Eastern populations more silvery than those from Western Australia.

Distribution

Both marine and estuarine with a range extending from Mandurah, south of Perth in Western Australia (Potter *et al.* 1986), along the entire coast of northern Australia to Clearview, 125 km south of Mackay, Queensland, also off islands in the Gulf of Carpentaria and north-east Queensland. Often schooling together with *C. capreoli* in Western Australia and Northern Territory.

Craterocephalus honoriae (Ogilby)

Figure 3

Atherina honoriae Ogilby, 1912: 42, type locality: Nerang Creek, Queensland, 28°12′S, 153° 14′E.

Craterocephalus honoriae – Jordan and Hubbs 1919: 45; – McCulloch and Whitley 1925: 140; – McCulloch 1929: 110.

Stenatherina honoriae – Schultz 1948: 22; – Munro 1958: 103; – Thomson 1959: 365.

Material examined

Nerang Creek, Queensland, holotype: QM I.598; paratypes: AMS I.12461 (3). Other specimens: Stradbroke Island, Queensland, AMS IB.1340 (1); Toukley, NSW, AMS IB.1410 (1);

Tuggerah Lakes, NSW, MQU 70-49a (10); Smith's Lake, near Myall Lake, NSW, AMS I.15321-006 (12). Size range 22-43.6 mm SL. Twenty-eight specimens used for measurements and counts.

Material examined for osteology: Unregistered specimens (5), Smith's Lake, NSW.

Diagnosis

A hardyhead of estuaries or coastal lakes most closely related to *C. mugiloides*, but differing from that species by absence of black spot at base of pectoral fin and in the proportion: length of premaxillary process in eye [1.5 (1.2-2.0) v. 1.2 (1.0-1.5)]. Osteologically *C. honoriae* differs from *C. mugiloides* by the smaller lateral process on the premaxilla. *C. honoriae* differs from all other marine/estuarine *Craterocephalus* by the combination of the following characters: snout 1.3-1.9 (1.5), premaxilla 1.0-1.6 (1.3) both in diameter of eye. Midlateral scales 33-36 (usually 33); gill rakers less than half diameter of pupil 12-15 (usually 13) (see Table 2). Teeth always present on mesopterygoid and frequently present on vomer. Posterior process of pelvic girdle very short.

Description

Slender fish; mouth small. Lips thin, fusing two-thirds way along premaxilla. Teeth well developed on both jaws. Premaxilla almost reaching vertical through anterior margin of eye or in some specimens slightly beyond. Dorsal process of premaxilla marginally shorter than in other marine/estuarine species. Scale crenulation, if present, almost imperceptible. Anus just in front or up to two scales in front of ventral tips.

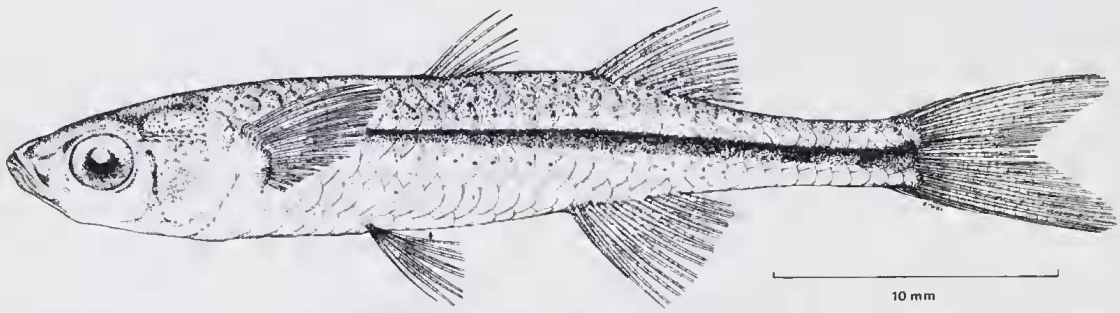

Figure 3 *Craterocephalus honoriae*, MQU I. 291 (32.6 mm SL), Currarong, N.S.W.

Colour: Preserved specimens varying from light brown with dark midlateral band (from pectoral fin to base of caudal fin) in old specimens, to pale or silvery yellow in fresh or recently preserved material. Silvery sheen lost soon after death. Eyes and opercle silvery; interorbital region and dorsal surface of body darkly pigmented. Some specimens with row of chromatophores directly below midlateral band. Live specimens dark yellow to greenish brown. Edges of scales above midlateral band outlined by chromatophores. Bases of unpaired fins dark. Opercle,

eye and abdomen often silvery. Midlateral band silvery or gold. Silvery peritoneum over abdominal cavity usually visible through skin.

Distribution

Appears to be exclusively estuarine, occurring on the eastern coast of Australia from Norwa (Currarong) in southern New South Wales to Moreton Bay in southern Queensland. Often schools together with another atherinid, *Atherinosoma microstoma,* in the southern half of its range.

Craterocephalus capreoli Rendahl

Figure 4

Craterocephalus capreoli Rendahl, 1922: 175, type locality, Roebuck Bay, Western Australia, 17°59′S, 122°15′E; – McCulloch 1929: 109; – Whitley 1943: 135; – Munro 1958: 102.
C. anticanus Whitley, 1955: 159, type locality: Roebuck Bay, Western Australia; – Munro 1958: 102.
C. pauciradiatus – Taylor 1964: 136; – Ivantsoff 1978: 237; – Patten 1978: 15.
C. capreolus – Pethon 1969: 6.

Material examined

Roebuck Bay, Western Australia, holotype of *C. capreoli* ZMUO J993, paratype BMNH 1922.1.14.I (1); Shark Bay, Western Australia, holotype of *C. anticanus* AMS IB.282; paratypes of *C. anticanus* AMS IB.283-289 (7); Abrolhos, Western Australia, AMS IB.1628 (3), AMS IB.1633 (5); Cape Peron, Shark Bay, Western Australia, AMS IB.1639 (6); AMS IB. 1654 (1). Other specimens: Cape Peron, Shark Bay, Western Australia, AMS IB.1640 (2); Hamelin Pool, Shark Bay, Western Australia, MQU 74-18 (10); Nightcliff, Darwin, Northern Territory, AMS I.15655-001 (1); Yirrkalla, near Cape Arnhem, Northern Territory, AMS I. 15653-002 (2); Eighty Mile Beach, Western Australia, DR 1969-77 (1); Mandu Mandu Creek, Western Australia AMS I.17725-001 (9), DR 1969-56 (21); Point Samson, Western Australia MQU 75-18 (2); Broome, Western Australia, MQU 75-23a (11); Lake McLeod, Western Australia, MQU 76-9 (7); Exmouth Gulf, Coral Bay, Western Australia, MQU 75-26 (9). Size range 30-69.9 mm SL. Of above, 43 specimens were used for measurements and counts.

Material examined for osteology: Unregistered specimens, Broome, Western Australia (2), Port Hedland, Western Australia (2).

Diagnosis

An estuarine species of *Craterocephalus* most closely related to *C. pauciradiatus,* but distinguished from that species by shape and number of gill rakers [10-13 (usually 11-12) never tuberculate v. 8-9 (usually 9) tuberculate]. Osteologically *C. capreoli* may be distinguished from *C. pauciradiatus* by the fifth ceratobranchials, not fused v. fused. *C. capreoli* differs from the other marine/estuarine species of *Craterocephalus* by a combination of the following characters: midlateral scales 29-33 (usually 31); vertebrae 30-35 (usually 32). Gill rakers short but not tuberculate, 10-13 (usually 11-12); anus 3-5 (usually 4) scales in front of tips of ventral fins (see Table 2). Anterior process of articular reaching into Meckelian fossa of dentary; epiotic crest with two fingerlike projections posteriorly, large fifth ceratobranchials very close but never fused.

Description

Moderately robust fish; mouth with relatively thin lips, point of fusion of lips varying from half to two-thirds way along premaxilla. In most specimens premaxilla reaching vertical through anterior edge of orbit; dorsal process of premaxilla long and moderately narrow. Teeth in upper and lower jaws in two rows, small but conspicuous, other bones edentulate. Posterior edge of body scales irregular in larger fish. Anus almost at base of ventral fins.

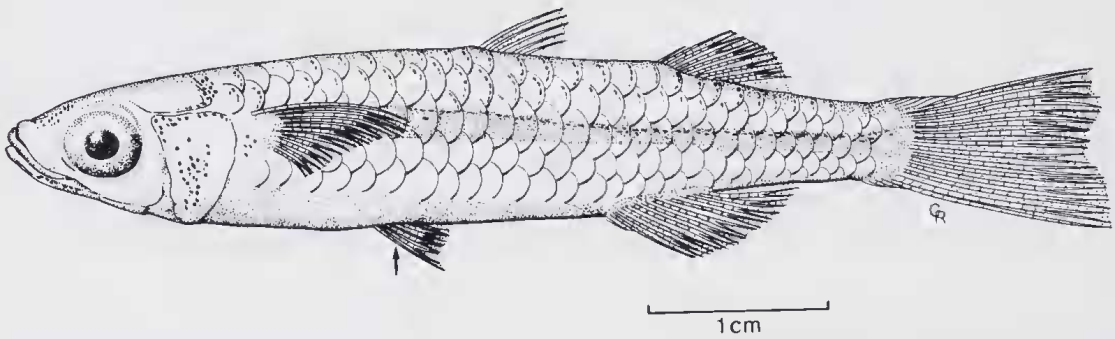

Figure 4 *Craterocephalus capreoli,* MQU I. 414 (41.6 mm SL), Beach at Exmouth, Exmouth Gulf, W.A.

Colour: Preserved specimens variable but usually pale to sandy yellow with silvery midlateral band extending from pectoral fin to hypural joint. Scales above midlateral band edged with chromatophores. Live specimens pale green or yellow, with silvery abdomen and midlateral band; body often with iridescent sheen.

Distribution

A wide ranging, essentially marine species, extending from Abrolhos Islands, Western Australia, to the Gulf of Carpentaria, Northern Territory. Capable of withstanding high salinities. Lenanton (1977) reported collections from Shark Bay, with salinity as high as 53-56 parts per thousand. *C. capreoli* has been collected together with *C. mugiloides, C. pauciradiatus* and *Atherinomorus endrachtensis,* in various localities in Western Australia.

Craterocephalus pauciradiatus (Günther)

Figure 5

Atherina pauciradiata Günther, 1861: 401, type locality: 'northwest coast of Australia'; – Macleay 1881: 39.

Craterocephalus pauciradiatus – Jordan and Hubbs 1919: 46; – McCulloch 1929: 110; – Whitley 1943: 135; – Munro 1958: 102.

Material examined

Northwest coast of Western Australia, syntype BMNH 1855.9.19.1513 (1). Other specimens: Exmouth Gulf, southern end of Bay of Rest, Western Australia, MQU I.202 (19); Cleaverville Creek, Western Australia, MQU I.308 (2), MQU I.309 (6), MQU I.310 (2). Size range 25.9-50 mm SL. Twenty-nine specimens were used for measurements and counts, syntype excluded.

Material examined for osteology: MQU I.202 (3), Exmouth Gulf, southern end of Bay of Rest, Western Australia.

Diagnosis

A robust estuarine species of hardyhead most closely related to *C. capreoli,* but distinguished from that species by the gill rakers [tuberculate, 8-9 (usually 9) v. 10-13 (usually 11-12) never tuberculate]. Osteologically *C. pauciradiatus* differs from *C. capreoli* in having fifth ceratobranchials fused v. unfused. *C. pauciradiatus* differs from other marine and estuarine species of *Craterocephalus* by a combination of the following: greatest body depth in SL 3.8-4.5 (4.1): eye in head 3.2-3.5 (3.3). Midlateral scales 27-30 (usually 29), vertebrae 30-32 (usually 31). Gill rakers very short and tuberculate, 8-9 (usually 9). Second dorsal fin rays 4-5 (usually 5) (see Table 2). Fifth ceratobranchials fused. Urohyal with ventral pocket. Interdorsal pterygiophores present but vestigial.

Description

Most robust of the marine/estuarine fish; mouth moderately large, lips relatively thick, fusing more than half way along premaxilla. Premaxilla almost reaching vertical through anterior margin of orbit, its dorsal process extending into interorbital space. Single row of minute teeth in upper and lower jaws. Scales large, posterior edge irregular on lateral surface and crenulated on dorsal surface in larger specimens. Anus half way between base and tips of ventral fins.

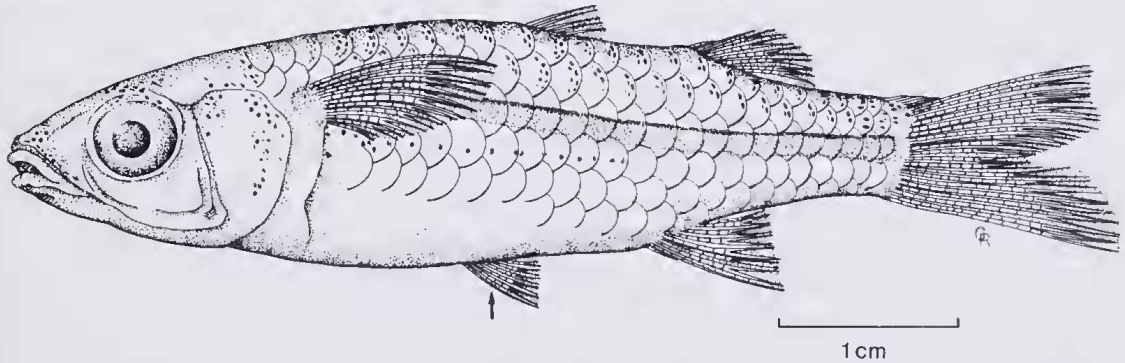

Figure 5 *Craterocephalus pauciradiatus,* MQU I. 412 (44.6 mm SL), Cleaverville Creek, W.A.

Colour: Preserved specimens variable from creamy-grey to yellow. Midlateral band dark or silvery, of even width from pectoral fin to hypural joint but breaking up into conspicuous chromatophores at caudal fin base. Small spots on each

scale in one or more scale rows below midlateral band from base of pectoral fin to about origin of anal fin. Scales above midlateral band, dorsum of head, jaws and opercle peppered with chromatophores to various degrees. Horseshoe shaped dark band immediately behind premaxilla on dorsum of snout. Ventral contour as double row of chromatophores from anus to base of caudal fin. Light pigmentation on caudal, first and second dorsal fins. Live specimens greenish yellow, midlateral band silvery or blackish with thin greenish iridescent border above. Abdomen often silvery, peritoneal lining and swimbladder visible. Opercle and iris silvery or iridescent green. Upper half of body and all fins dusky.

Distribution

An uncommon, predominantly marine species, recorded only from about 400 km of coastline between Exmouth Gulf and just north of Karratha, in Cleaverville Creek, Western Australia. The species is poorly known and has been confused with *C. capreoli* (Taylor, 1964; Ivantsoff, 1978) until recently. *C. pauciradiatus* has been collected together with two other atherinids, *C. capreoli* and *Atherinomorus endrachtensis.*

Additional osteological comparison of the marine/estuarine species of *Craterocephalus*

C. mugiloides: fifth ceratobranchials narrow, shallow triangles, not closely joined; basibranchial tooth plate present. Dentary narrow; anterior of dentary deep; labial ligament extending to symphysis. Anterior process of articular not reaching Meckelian fossa. Teeth often present on mesopterygoid. Epiotic crest small; urohyal ventral wings small. Interdorsal pterygiophores (5-6) well developed. Ethmoid cartilage persisting in palatine facet in some specimens.

C. honoriae: fifth ceratobranchials large, triangular but not closely joined; basibranchial tooth plate present. Dentary narrow; anterior dentary shallow; labial ligament not reaching symphysis. Anterior process of articular not reaching Meckelian fossa. Teeth always present on mesopterygoid. Epiotic crest small; urohyal ventral wings small. Interdorsal pterygiophores (5-6) well developed. Ethmoid cartilage never present in palatine facet.

C. capreoli: fifth ceratobranchials large, triangular, very close but not joined; basibranchial tooth plate present. Dentary broad; anterior dentary shallow; labial ligament not reaching symphysis. Anterior process of articular extending into Meckelian fossa. Teeth absent on mesopterygoid. Epiotic crest with usually two finger-like posterior projections. Urohyal ventral wings small. Interdorsal pterygiophores (4) well developed; no ethmoid cartilage in palatine facet.

C. pauciradiatus: fifth ceratobranchials fused; basibranchial tooth plate present. Dentary broad; anterior dentary shallow; labial ligament almost reaching

symphysis. Anterior process of articular not reaching Meckelian fossa. Teeth absent on mesopterygoid. Epiotic crest with bladelike posterior projection. Urohyal ventral wings large. Interdorsal pterygiophores (5) small to vestigial. No ethmoid cartilage in palatine facet.

C. munroi: fifth ceratobranchials fused; basibranchial tooth plate absent. Dentary broad; anterior dentary shallow. Labial ligament not reaching symphysis. Anterior process of articular not reaching Meckelian fossa. Teeth absent on mesopterygoid. Epiotic crest extending backwards as triangular projection. Urohyal ventral wings small. Interdorsal pterygiophores absent or if present (1-2), vestigial. No ethmoid cartilage in palatine facet.

Systematic relationships of the marine/estuarine species of *Craterocephalus*

Although the status of the genus *Craterocephalus* has never been questioned since its description by McCulloch in 1913, there had not been a systematic study of relationships of the members of the genus until Ivantsoff's and Patten's studies in 1978. Patten defined the genus on the basis of the following unique characters: anterior arms of lateral ethmoids converging anteriorly, forming strong joint with either side of vomer, usually excluding ethmoid cartilage from palatine facet; mesethmoid absent or reduced to small rudiment; premaxilla with slender dorsal process, distal end of alveolar arm broad; ethmomaxillary ligament absent; nasal with distinct palatine process for palatine-nasal ligament; coronoid-premaxilla ligament present; parasphenoid only superficially embedded in basioccipital.

Patten (1978) suggested that *Craterocephalus honoriae* was the most primitive member of the genus and was probably closest to the hypothetical ancestor of the group. *C. capreoli* (identified as *C. pauciradiatus*) was considered to be more advanced but not necessarily more related to any of the other species of the genus. Although he placed *C. pauciradiatus* (at the time identified as *Craterocephalus* sp.) into the *stercusmuscarum* group he noted that it essentially was most similar to *C. capreoli* and *C. honoriae* except for the pharyngeal mechanism. The present study shows that all of the species above, as well as *C. mugiloides,* share the presence of posterior basibranchial tooth plate whilst the posterior angle of the coracoid is at the level of the ventral end of the cleithrum (Figure 6). These features are also shared with the freshwater atherinid *Craterocephalus stramineus* (= *Quirichthys stramineus* Whitley, 1950 – the status of this freshwater species is currently under investigation).

Although *C. mugiloides* has several unique features – labial ligament extending to symphysis of dentary, persistence of ethmoid cartilage in some adults and a small ethmoid ossification in about half of the specimens – Patten (1978) could

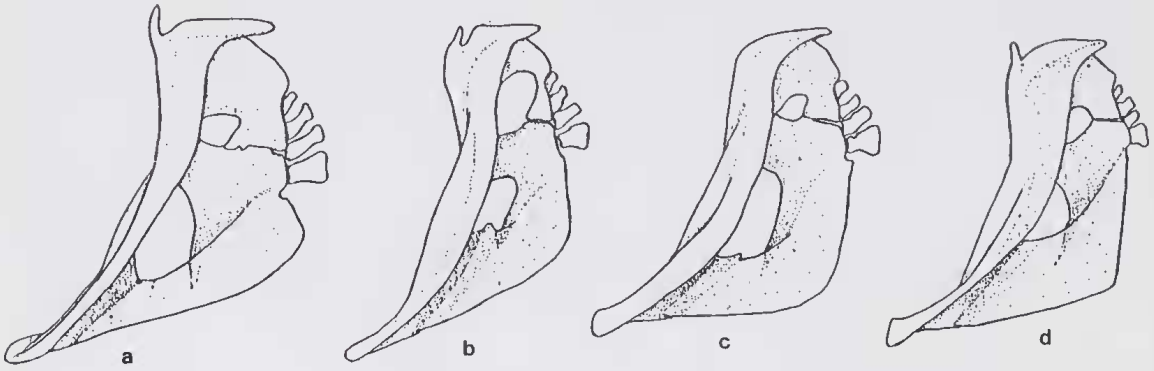

Figure 6 Pectoral girdles of a) *C. s. stercusmuscarum*, b) *C. marianae*, c) *C. stramineus* and d) *C. pauciradiatus*, to show the three basic shapes of coracoid. All species of the *C. stercusmuscarum* group are similar to a); all *C. eyresii* species members have pectoral girdles similar to b); all the *C. honoriae* species group as well as *C. stramineus* are similar, c) and d).

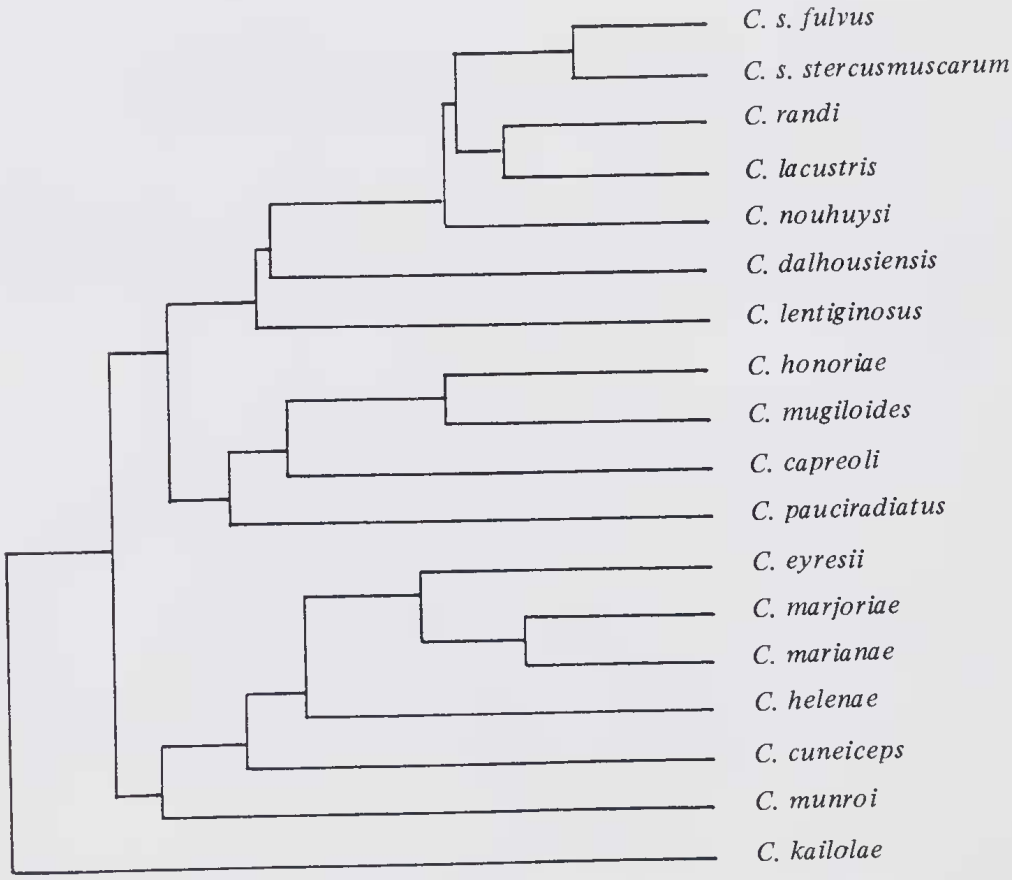

Figure 7 Cluster analysis of all *Craterocephalus* species (excluding *C. stramineus*) to indicate the three species groups.

find no advanced characters to define *Allanetta* as a separate genus. There appears to be no justification to separate this species into a subgenus (Patten 1978) or a genus of its own since it shares all other characters on the basis of which *Craterocephalus* is diagnosed. The *honoriae* group therefore includes all of the marine/estuarine species with the exception of *C. munroi*. On the basis of other characters, two pairs of sister species can be recognised within the *honoriae* group (see Table 3). A cluster analysis, based on osteology, of all *Craterocephalus* species (excluding *C. stramineus*) showing the three major species groups and relationships within those groups is presented in Figure 7. *C. honoriae* and *C. mugiloides* have characters which are considered most primitive (e.g. mesopterygoid and vomerine teeth, wide separation of fifth ceratobranchials) for the genus.

Table 3 Osteological characters shared by the two marine/estuarine species pairs of *Craterocephalus*. Species pair A *(C. honoriae, C. mugiloides);* species pair B *(C. capreoli, C. pauciradiatus).*

Character	Species pair
Teeth usually present on vomer, mesopterygoid	A
Teeth never present on vomer, mesopterygoid	B
Anterior dentary narrow	A
Anterior dentary broad	B
Epiotic crest small	A
Epiotic crest large, fingerlike	B
Dorsal process of cleithrum pointed	A
Dorsal process of cleithrum blunt	B
Gill rakers nearly half diameter of pupil, never less than 12	A
Gill rakers short or tuberculate, always less than 13	B

C. munroi has no basibranchial tooth plate, vomerine or mesopterygoid teeth and the interdorsal pterygiophores are usually absent. The fusion of the fifth ceratobranchials and the reduction of the pelvic girdle medial wing suggests that *C. munroi* is an advanced member of the *C. eyresii* group.

The distribution of the species pair *C. mugiloides* and *C. honoriae* suggests that divergence between these species must have occurred during periods of emergence of the Torres land bridge when ancestral populations could have been separated for long periods (Eocene/Oligocene or more recently during Plio-Pleistocene [see Dow 1977]), and prior to the present Torres Strait/Arafura Sea transgression. The divergence between the marine and freshwater species of this genus may have occurred in early Tertiary, although some authors consider that speciation of Australian freshwater fishes may be of recent origin (Whitley 1959; Allen and Cross 1982). An electrophoretic study of all *Craterocephalus* species from Australia and New Guinea (including the closely related

C. randi and *C. s. stercusmuscarum*) currently under way, should provide some evidence of the recency or otherwise of divergence of some of the species. Other systematic studies of the genus *Craterocephalus* are in progress and some of this work is already reported (Ivantsoff *et al.* 1987b).

Acknowledgements

We thank Mrs Gillian Rankin and Miss Betty Thorn for the drawings of the specimens. Ms Jenny Norman is thanked for her assistance with photography and Dr G.M. McKay for his assistance with computing. We are most grateful to Dr Steven Blaber and Mr Keith Bishop for the many specimens they have collected during their own field work and also for pointing out the best collecting sites. Finally we wish to express our gratitude to all the curators who were kind enough to lend us the material for our studies.

References

Allen, G.R. and Cross, N.J. (1982). *Rainbowfishes of Australia and Papua New Guinea.* Angus & Robertson, Sydney, London, New York, 141 pp.

Bennett, E.T. (1832). Characters of two new species of fishes, from the Mauritius presented by Mr Telfair. *Proc. Zool. Soc. Lond.* (2): 184.

Chessman, B.C. and Williams, W.D. (1974). Distribution of fish in inland saline waters in Victoria, Australia. *Aust. J. Mar. Freshwater Res.* 25: 167-72.

De Vis, C.W. (1885). New fishes in the Queensland Museum. *Proc. Linn. Soc. N.S.W.* 9(5): 869-887.

Dow, D.B. (1977). A Geological Synthesis of Papua New Guinea. *Bur. Miner. Resour. Aust. Bull,* 201, 41 pp.

Günther, A. (1861). Catalogue of the Acanthopterygian fishes in the British Museum, 3: 1-586, London.

Ivantsoff, V. (1978). Taxonomic and systematic review of the Australian fish species of the Family Atherinidae with references to related species of the Old World. Unpub. Ph.D. thesis, Macquarie University, Sydney, 701 pp.

Ivantsoff, W., Crowley, L.E.L.M. and Allen, G.R. (1987a). Description of a new species of freshwater hardyhead *Craterocephalus kailolae* (Pisces: Atherinidae) from Safia, north-eastern Papua New Guinea. *Proc. Lin. Soc. N.S.W.* 109 (4)(1986): 331-37.

Ivantsoff, W., Crowley, L.E.L.M. and Allen, G.R. (1987b). Descriptions of three new species and one subspecies of freshwater hardyhead (Pisces: Atherinidae: *Craterocephalus*) from Australia. *Rec. West. Aust. Mus.* 13 (2): 171-188.

Jordan, D.S. and Hubbs, C.L. (1919). A monographic review of the Family Atherinidae or silversides. *Stanford Univ. Publ., Univ. Ser.* 87 pp.

Jordan, D.S. and Richardson, R.E. (1908). Fishes from islands of the Philippine Archipelago. *Bull. U.S. Bur. Fish.* 27 (1907): 233-287.

Lenanton, R.C.J. (1977). Fishes from the hypersaline waters of the stromatolite zone of Shark Bay, Western Australia. *Copeia* (2): 387-390.

Macleay, W. (1881). Descriptive catalogue of the fishes of Australia. *Proc. Linn. Soc. N.S.W.,* 6: 1-138.

McCulloch, A.R. (1913). Notes on some Australian Atherinidae. *Proc. Roy. Soc. Qld.* 24 (1912): 47-53.

McCulloch, A.R. (1929). A check list of the fishes recorded from Australia. *Mem. Aust. Mus.* 5 (1): 1-144.

McCulloch, A.R. and Whitley, G.P. (1925). A list of the fishes recorded from Queensland waters. *Mem. Qld. Mus.* 8 (2): 125-182.

Munro, I.S.R. (1958). Family Atherinidae. In: *Handbook of Australian Fishes,* No. 24: 97-100, No. 25: 101-104. *Suppl. Aust. Fish. Newsl.* 17 (6): 17-20, 17 (7): 17-20.

Munro, I.S.R. (1967). The Fishes of New Guinea. Department of Agriculture, Stock and Fisheries, Port Moresby. 650 pp.

Ogilby, J.D. (1912). On some Queensland fishes. *Mem. Qld. Mus.* 1: 26-65.

Patten, J.M. (1978). Osteology, relationships and classification of hardyheads of the subfamily Atherinidae (Pisces: Atherinidae). Unpubl. M.Sc. thesis, Macquarie University, Sydney, 169 pp.

Patten, J.M. and Ivantsoff, W. (1983). A new genus and species of atherinid fish *Dentatherina merceri* from the western Pacific. *Jap. Jour. Ichthyol.,* 29 (4): 329-339.

Pethon, P. (1969). List of type specimens of fishes, amphibians and reptiles in the Zoological Museum, University of Oslo. *Rhizocrinus, Occ. Papers Zool. Mus. Univ. of Oslo.* 1 (1): 1-17.

Potter, I.C., Ivantsoff, W., Cameron, R. and Minard, J. (1986). Life cycles and distribution of atherinids in the marine and estuarine waters of southern Australia. *Hydrobiologia.* 139 (3): 23-40.

Prince, J.D., Ivantsoff, W. and Potter, I.C. (1982). *Atherinosoma wallaceii* a new species of estuarine and inland silverside (Teleostei: Atherinidae) from the Swan-Avon and Murray Rivers, Western Australia. *Aust. Zool.* 21 (1): 63-74.

Rendahl, H. (1922). A contribution to the ichthyology of north-west Australia. *Meddr. zool. Mus. Krist.* 5: 163-197.

Schultz, L.P. (1948). A revision of six subfamilies of atherine fishes, with descriptions of new genera and species. *Proc. U.S. Nat. Mus.* 98 (3220): 1-48.

Schultz, L.P., Herald, E.A., Lachner, E.A., Welander, A.D. and Woods, L.P. (1953). Fishes of the Marshall and Marianas Islands. 1. Families from Asymmetrontidae through Siganidae. *Bull. U.S. Natn. Mus.* 202 (1): 1-685.

Smith, J.L.B. (1965). Fishes of the Family Atherinidae of the Red Sea and Western Indian Ocean with a new freshwater genus and species from Madagascar. *Ichthyol. Bull. Rhodes. Univ.* 31: 601-632.

Sneath, P.H.A. and Sokal, R.R. (1973). Numerical Taxonomy. W.H. Freeman, San Francisco. 573 pp.

Taylor, W.R. (1964). Fishes of Arnhem Land. *Rec. Amer.-Austr. Exped. Arnhem Land, Zool.* 4 (3): 45-307.

Taylor, W.R. (1967). Outline of a method of clearing tissues with pancreatic enzymes and staining bones of small vertebrates. *Turtox News* 45 (12): 308-309.

Thomson, J.M. (1959). Some aspects of the ecology of Lake Macquarie, N.S.W., with regard to an alleged depletion of fish. ix. The fishes and their food. *Aust. J. Mar. Freshwater Res.* 10: 365-374.

Whitley, G.P. (1943). Ichthyological descriptions and notes. *Proc. Linn. Soc. N.S.W.* 68 (3, 4): 114-144.

Whitley, G.P. (1950). Studies in Ichthyology No. 14. *Rec. Aust. Mus.* 22 (3): 234-45.

Whitley, G.P. (1955). Opus CCC. *Aust. Zool.* 12 (2): 154-159.

Whitley, G.P. (1959). The freshwater fishes of Australia. In: *Biogeography and Ecology in Australia.* Keast, A., Crocker, R.L. and Christian, C.S. (eds), pp. 136-149. W. Junk. The Hague.

Received 24 March 1988 Accepted 18 May 1988 Published 23 December 1988